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THE RED SPIDER ON COTTON.

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

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THE RED SPIDER ON COTTON.¹

(*Tetranychus bimaculatus* Harvey.)

By E. A. MCGREGOR,
Entomological Assistant.

INTRODUCTION.

The minute reddish mite commonly known as the red spider apparently is becoming one of the serious enemies of the cotton plant in the United States. It is now prevalent throughout the cotton belt, and, especially in the last few seasons, has caused much alarm among the farmers in certain sections. Seasons of excessive drought are favorable to the development of the mite, and at such times the pest increases so rapidly that the damage often becomes severe before its presence is detected.

Red-spider infestation is frequently miscalled "rust" by farmers, since infested leaves soon turn deep red on their upper surface. Such leaves, however, if examined underneath, reveal the presence of the red spiders and the inconspicuous webs behind which they are feeding and laying their eggs.

HISTORY AND DISTRIBUTION.

With the exception of an outbreak in Louisiana, reported by Prof. H. A. Morgan in 1893, severe occurrence of the red spider on cotton had not been reported until 1903, at which time complaints of damage came from South Carolina and Georgia. In 1904 Mr. E. S. G.

¹ This circular is based primarily upon work done at Batesburg, S. C., in 1911 and 1912, under the direction of Mr. W. D. Hunter, but also includes the results of observations by Messrs. G. A. Runner and H. F. Wilson during the two preceding seasons. It is a revision of and supersedes Circular No. 150.

Titus, then of this bureau, found severe infestation in fields about Batesburg, S. C., and the following year he reported severe injury in North Carolina, South Carolina, Georgia, and Alabama. Since then the additional records of Dr. F. H. Chittenden and Messrs. G. P. Weldon, D. T. Fullaway, and others, as well as the writer, have established the presence of this red spider from Maine to Florida and westward to California and in the Hawaiian Islands. With the exception of western Colorado and portions of California no complaints of an alarming nature regarding this pest have come to the writer's attention other than from the southeastern portion of the cotton belt. It is here that the red spider appears to have found the conditions most suitable for its development.

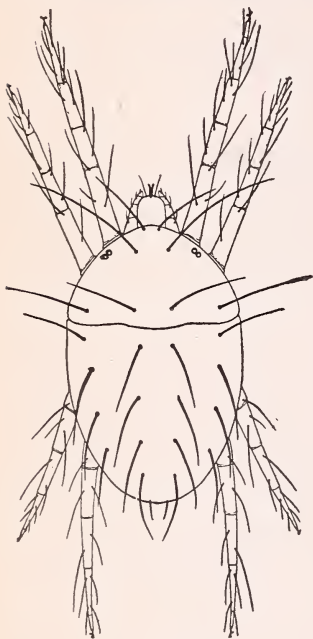


FIG. 1.—The red spider, *Tetranychus bimaculatus*: Adult female. Greatly enlarged. (From Banks.)

The red spider was described by Harvey in 1893 as *Tetranychus 2-maculatus*. Harvey considered it quite distinct from the European species *T. telarius* L. His types were from Orono, Me. In 1907 Prof. H. A. Morgan published observations on the cotton mite, and apparently accepted the determination of the species as *T. telarius*. In 1900 Mr. Nathan Banks described the cotton mite under a distinct name—*Tetranychus gloveri*—but from the study of additional specimens has now concluded that the name is synonymous with Harvey's *T. bimaculatus*. Specimens of red spiders on cotton from South Carolina have upon two recent occasions been determined by Prof. A. Berlese as the continental species—*Tetranychus telarius*. As there seems to

be considerable doubt on this point, we shall follow Mr. Banks in considering the form with which we are dealing as *Tetranychus bimaculatus*.

DESCRIPTION.

The typical female (fig. 1) is 0.50 mm. long by 0.26 mm. wide, broad-oval, widest in front, and the legs are shorter than the body. Its color is usually brick-red. The typical male is 0.27 mm. long by 0.15 mm. wide, oval-wedge shape, narrowed behind, the legs about equaling the length of the body, and its color is usually reddish amber. Individuals of both sexes usually possess on either side of the body a dark spot, caused by the food contents. This spot may vary greatly in color, size, and outline. Similarly, depending upon

the host plant and upon locality, the general color of the red spider is subject to great variation.

The eggs are very minute, but in proportion to the mites they are large. They are perfectly round, and when first laid are as clear as water. Each female lays (in the months of June, July, and August) about 50 to 60 eggs, although her brood may in cases exceed 100. Usually about 6 eggs are deposited per day for a period of 9 or 10 days. Less than 3 eggs or more than 10 are rarely deposited in one day in summer weather. During the warmer months the eggs hatch in about 4 days after being laid.

The newly hatched red spider, called the larva, is almost round, has six legs, and is nearly colorless. It begins feeding at once, and (in summer time) after two days' activity it becomes quiet, darkens in color, casts its skin for the first time, and emerges as the primary nymph with an added pair of legs—making eight.

The primary nymph becomes larger in size and darker in color, but gives no indication of sex. Feeding continues actively, and at the termination of another two-day period (in summer months) a second molting occurs, which gives rise to the third stage—the secondary nymph.

With this last nymphal stage the first indication of sex appears. As with the preceding stages, two days usually suffice in summer for the completion of this period, at the end of which time the skin is shed for the third time and at last the perfectly developed adult mites appear. At the occurrence of each molt the skin splits in two, crosswise, and the creature crawls out of the two halves. The old cast skins are usually to be seen in abundance among the fibrils of the web.

THE ADULT MALES AND FEMALES COMPARED.

Concerning the relative abundance of females and males it may be said that there seems to be a predominance of females throughout the summer, but toward the approach of cold weather the occurrence of the sexes becomes more nearly equal. The period of life of the adult female varies from 17 days in midsummer to several months in winter. The male is shorter lived. As before stated, the female is decidedly larger than the male, more rounded behind, and of a much deeper color. She does not move about much, and when she does her motion is rather slow. On the other hand, when not mating, the male is frequently seen moving rapidly about. The body and legs are well beset with bristles, which are somewhat more conspicuous in the males than in the females. In addition, the legs of the male are longer in proportion to the body than are those of the female. The legs of the first pair are especially long in the male, and are doubtless adapted for clasping. The eyes, consisting each of two orbs, one close behind the other, are situated near the front edge of the body directly over the second pair of legs.

MATING.

Almost immediately upon becoming adult, the red spiders mate and begin egg laying. The males seem to recognize unfertilized females with ease. The first eggs are frequently deposited on the same day upon which the transformation occurs from the last nymphal to the adult stage.

PARTHENOGENESIS.

Experiments conducted with unmated female red spiders clearly prove that they are normally capable of laying eggs, which in turn hatch and develop into mature individuals. No tests, however, have been successfully conducted to determine the sexual fertility of the latter.

GENERATIONS.

The season of 1911 at Batesburg, S. C., was one of unusual drought and heat, and there were about 17 generations between March 11 and November 5. The time required for a single generation varied from 35 days in March and early April to 10 days throughout most of June, July, and August, and to 25 days in the greater portion of October and early November. During the same period of 1912 at Batesburg only 16 generations were produced. The 1912 season was late in commencing, was somewhat cooler than that of 1911, and more showers occurred. From April 24 to September 25 there was small variation in the time required for the generations—averaging about 11 days. Two generations developed each in 9 days, which is less than was required for any brood in 1911. Thirty days was required for the October-November generation. The following table presents the duration of each stage of each of the 17 generations for 1911:

TABLE I.—*Development of generations of the red spider on cotton in 1911.*

Generation.	Period covered by generation.	Incubation period.	Larval period.	Nymph (1) period.	Nymph (2) period.	Oviposition to adult.
		<i>Days.</i>	<i>Days.</i>	<i>Days.</i>	<i>Days.</i>	<i>Days.</i>
1.....	Mar. 11 to Apr. 14.....	13	9	6	7	35
2.....	Apr. 15 to Apr. 29.....	6	3	3	3	15
3.....	Apr. 30 to May 13.....	6	3	3	2	14
4.....	May 14 to May 25.....	5	3	2	2	12
5.....	May 26 to June 6.....	5	3	2	2	12
6.....	June 7 to June 17.....	4.5	2.5	2	2	11
7.....	June 18 to June 27.....	4	2	2	2	10
8.....	June 28 to July 7.....	4	2	2	2	10
9.....	July 8 to July 18.....	4	2.5	2.5	2	11
10.....	July 19 to July 28.....	4	2	2	2	10
11.....	July 29 to Aug. 7.....	4	2	2	2	10
12.....	Aug. 8 to Aug. 17.....	4	2	2	2	10
13.....	Aug. 18 to Aug. 29.....	5	2.5	2	2.5	12
14.....	Aug. 30 to Sept. 9.....	5	2	2	2	11
15.....	Sept. 10 to Sept. 24.....	5	3.5	3	3.5	15
16.....	Sept. 25 to Oct. 10.....	6	3	3	4	16
17.....	Oct. 11 to Nov. 4.....	9	6	5	5	25
	Average.....	5.5	3.1	2.7	2.8	14

Table II indicates the duration of, and the period covered by, each of the 16 generations for 1912 as well as for the 1911-12 wintering generation.

TABLE II.—*Development of generations of the red spider on cotton in 1912.*

Gener- ation.	Period covered by generation.	Dura- tion.	Gener- ation.	Period covered by generation.	Dura- tion.
		<i>Days.</i>			<i>Days.</i>
1 ¹	Nov. 5, 1911, to Apr. 23, 1912.....	170	11.....	Aug. 3 to Aug. 14.....	12
2.....	Apr. 24 to May 5.....	12	12.....	Aug. 15 to Aug. 24.....	10
3.....	May 6 to May 17.....	12	13.....	Aug. 25 to Sept. 2.....	9
4.....	May 18 to May 29.....	12	14.....	Sept. 3 to Sept. 12.....	10
5.....	May 30 to June 9.....	11	15.....	Sept. 13 to Sept. 24.....	12
6.....	June 10 to June 21.....	12	16.....	Sept. 25 to Oct. 11.....	17
7.....	June 22 to July 3.....	12	17.....	Oct. 12 to Nov. 19.....	30
8.....	July 4 to July 14.....	11			
9.....	July 15 to July 24.....	10		Average since Apr. 23.....	12.6
10.....	July 25 to Aug. 2.....	9			

¹ This is the wintering generation and should hardly be counted with the 1912 broods.

RELATION OF WEATHER TO BREEDING ACTIVITIES.

The influence of the weather on breeding activity is very noticeable. Hot, dry conditions greatly favor and hasten development, while cool, wet weather correspondingly retards it. A female laying normally about 6 or 7 eggs per day will often upon the occurrence of a very hot day suddenly increase the number to 15 or even more eggs per day, or upon a chilly day may drop as suddenly to 1 or 2 eggs. It is easy then to understand the remarkable rate at which this pest increases during times of unusual drought.

OBSERVATIONS ON HABITS.

In establishing herself upon cotton the female selects a concave area between the under veins of the leaf and begins at once to deposit eggs. These may be attached to the fibrils of the web slightly above the surface, or, as seems most often the case, they are placed directly upon the leaf. The eggs are usually clustered rather closely and rarely occupy an area greater in size than that of a dime. Feeding continues interruptedly throughout the period of egg laying, and the affected area of the leaf becomes thickly dotted with the blackish-green puncture marks. Meanwhile a wine-red spot has appeared on the upper surface of the leaf directly over the young colony, which spreads as the colony increases and may finally color the entire leaf. As the eggs hatch the larvæ remain close to the place of their birth. The mites seem to be decidedly gregarious. In a young colony there is usually little web formed, but where the spiders are very abundant the web may become quite conspicuous. It doubtless affords some protection from adverse weather conditions, as well as against hostile intruders, since upon several occasions predaceous

insects have been observed ensnared and dead among the fibers. New females, after mating, either select an attractive spot on the leaf, or migrate upward to a more tempting leaf, or, as frequently is the case when overcrowded, travel to another plant.

THE VIOLET AND POKEWEED AS HOSTS.

When cotton dies or becomes untempting in the late fall an exodus of red spiders from the cotton fields occurs in the effort to find more suitable food plants. At this time cotton mites may be easily found on a number of native and cultivated plants, prominent among which are cowpeas, tomato, Jamestown weed, ironweed, pokeweed, and cultivated violets. Most of these plants die after the frosts, but pokeweed furnishes considerable green tissue beneath the ground level,

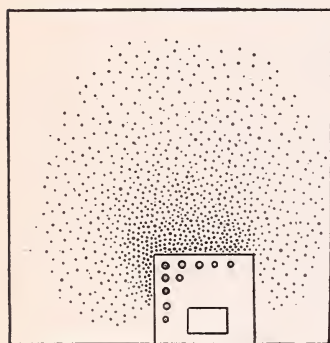


FIG. 2.—Diagram showing how violets growing in dooryard give rise to red-spider infestation in adjoining field. The infestation is most severe near the yard. This diagram is typical of many cases found during 1911. (Author's illustration.)

and the violet remains somewhat green throughout the winter. Out of many cases of cotton infestation investigated during the last two seasons the vast majority of them have indicated most clearly that the original source of the pest was either the English violet (figs. 2, 3) or pokeweed (*Phytolacca decandra*) (fig. 4).

Practically all occurrences in urban localities have been intimately associated with cultivated violet plants and doubtless originated from them. On the other hand, with very few exceptions rural cases of infestation are traceable to pokeweed stalks growing at the field borders or on the terraces. The description of a rural occurrence at

Allendale, S. C., will serve to illustrate a typical case of origin from pokeweed. In this instance the infestation was seen to grow increasingly severe as one approached a certain point on a terrace. Converging from all directions toward this center, infestation clearly became heavier until an area was reached where the plants were denuded of foliage. Precisely in the center of this area there grew a large pokeweed stalk. It was "alive" with mites and was lightly festooned with their webbing.

It is not yet entirely clear in what manner the red spider passes the winter on pokeweed. The plant is a perennial, and the stalks die to the ground in the late fall. Just below the soil surface, however, the soft fleshy roots, which are succulent, begin (fig. 4). In addition, at the crown of the root, at about the ground level, there are always

to be found through the winter months the tender dormant buds which give rise to the stalks of the following season. Upon November 23, 1912, following several severe frosts at Batesburg, S. C., a few of the mites were seen, apparently feeding on these winter buds.

OTHER HOSTS.

As a result of the investigations at Batesburg, together with the earlier observations of the red spider on cotton, this mite has been seen upon over 90 species of plants, including weeds, ornamental plants, and garden and field crops. Upon most of these the pest has only occasionally been seen, but it has been found commonly through-

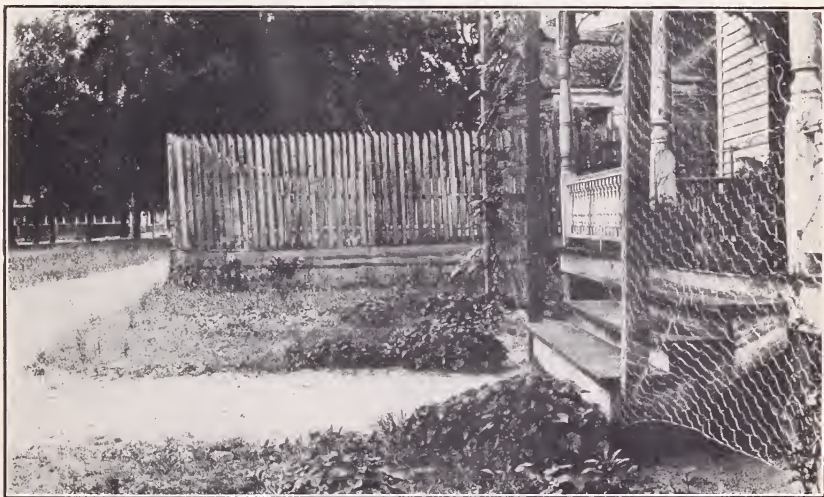


FIG. 3.—Typical violet borders and patches growing in dooryard. (These particular plants constituted the source of dispersion which resulted in the severe infestation of a small cotton field directly across the road.) (Original.)

out the active season upon the following plants: Beans, cowpeas, dahlia, ironweed, Jerusalem-oak weed, Jamestown weed, okra, tomato, wild blackberry, wild geranium, pokeweed, and English violet. At Brownsville, S. C., August 8, 1912, a case was seen where a field of corn was immediately adjacent to a badly infested cotton patch. The infestation had spread into the corn and the cowpeas growing between the corn rows. One-fourth of the corn had been pulled up and the balance was very severely infested. Many of the cornstalks exhibited large rusty-yellow blotches on their blades and, in fact, had the pest appeared when the corn was younger it probably would have ruined the crop. On the cowpeas the infestation was heavy, many of the leaves had dropped, and those remaining were discolored and distorted.

HIBERNATION VERSUS WINTERING.

Some observers have thought that the red spider commonly hibernates in trash or in the soil in cotton fields, but the investigations in South Carolina have produced absolutely no evidence to support this idea. During the late fall and early spring, when the weather was

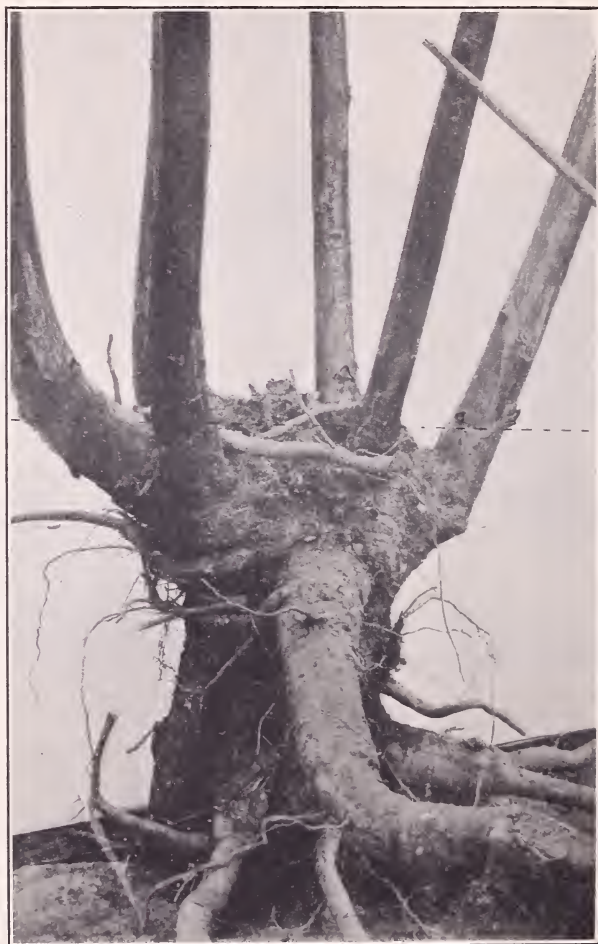


FIG. 4.—System of fleshy roots of the pokeweed (*Phytolacca decandra*), showing the attractive winter buds at about the ground level, as indicated by the dotted line. (Original.)

as cold as it becomes in South Carolina, trash has been taken several times from fields in which the infestation had previously been severe and examined with great care. A few minute dormant acarids and other forms have thus been obtained, but no red spiders have been found in such material.

That this pest remains more or less active throughout the winter there can be no doubt. Mr. G. A. Runner found active adults at Batesburg, S. C., on December 21, 1909. Mr. H. F. Wilson observed red spiders feeding in early February at the same locality. The writer found all stages alive on English violets on March 11, and adults as late as December 19 at Batesburg on the same host in 1911. Adults were seen alive on violets at Batesburg on February 23, 1912, following the coldest winter that section had experienced for many years.



FIG. 5.—An uninfested cotton plant, growing in same field as shown in figure 9, but just beyond the boundary of infestation by the red spider. (Original.)

The finding of the active red spiders during the coldest weather is certainly an additional indication that hibernation does not take place in South Carolina.

DISPERSION.

How do red spiders become established upon cotton? They have no wings and their legs are very minute. Close observations reveal that on the ground they normally travel at the rate of 1 inch per 15 seconds, which, if maintained, would total 480 feet in 24 hours. Red spiders are doubtless occasionally transferred by dogs, chickens,

other domestic animals, insects, and birds. Strong winds may serve occasionally to transfer them from plant to plant. It is the writer's firm belief, however, that the chief means of dispersion is the red spider's own efforts. When once established in a field they may be further distributed by farm hands and by stock while cultivation is being carried on. They also spread from plant to plant along the interlacing branches, but traps specially prepared, with tanglefoot and placed in the field have proven that individuals commonly crawl from plant to plant by way of the stalk and the ground.

Since the red spider apparently uses no instinct or intelligence in finding cotton plants, it follows that the pest must hit upon the cotton stalks entirely by chance. The result of this haphazard manner of migration must necessarily result often in the penetration of the spiders far into the center of fields, thus giving rise to the mistaken impression that they had hibernated at these points.

Furthermore, as the likelihood of the discovery of cotton by the spider is doubtless in proportion to the thickness of the "stand," it should follow that the thick broadcasting of a narrow border strip along the edge of a field adjoining a source of infestation would serve as a trap crop to intercept the majority of migrating spiders. This strip should be plowed in as soon as there seems to be danger of a general movement to the main field. (For a practical test of this idea, see under Prevention, p. 17.)

There is an old adage which has come to the writer's attention several times the past season from the lips of old planters: "When the pokeweed turns red, look out for the cotton 'rust.'" This expression, said to have been employed in antebellum days, is of considerable interest, since it contributes evidence tending to prove the long existence of the cotton mite in the South, as well as the function of the pokeweed.

TIME OF APPEARANCE AND DISAPPEARANCE.

In 1911 the work of the pest on cotton first became noticeable about June 1 at Batesburg. The past season (1912), however, red-spider work was not evident on cotton until about the last of June at that locality. From the answers to a large number of inquiries sent to farmers throughout South Carolina, the average time of first appearance in fields the past season is found to have been June 30. The lower (sandy) section of the State averages one-half month earlier in the pest's arrival than does the upper (clay) section—June 25 marking the arrival time for the former and July 10 for the latter. Although the pest does not become readily noticeable on cotton until some time in June, it really establishes itself considerably earlier. Mites have occasionally been seen by the 1st of May on seedling plants not over

2 inches high. In both 1911 and 1912 the pest abandoned cotton about the last of August. This makes the period of activity cover about 12 weeks.

NATURE OF DAMAGE.

The presence of the pest on cotton is first revealed by the appearance on the upper surface of the leaf of a blood-red spot. As leaves become badly infested they redden over the entire surface, become

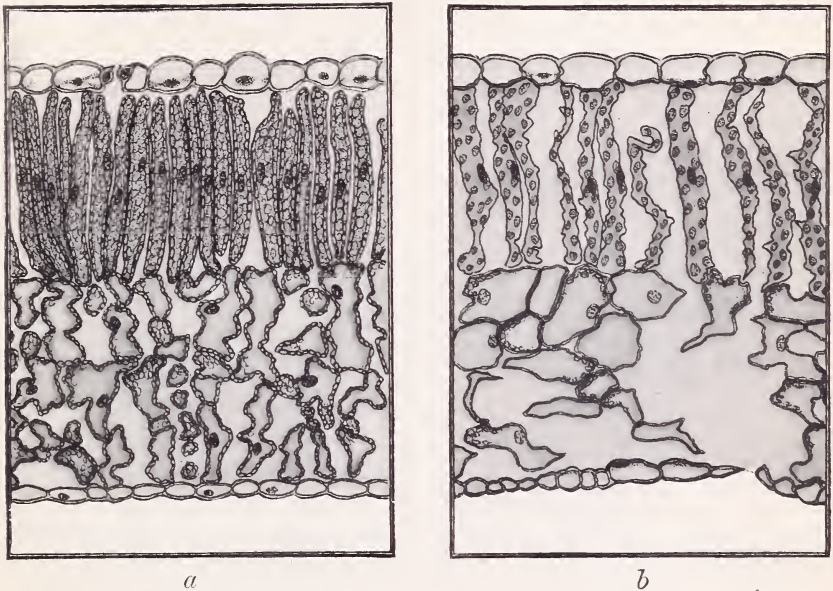


FIG. 6.—*a*, Cross section of normal cotton leaf; *b*, cross section of cotton leaf injured by the red spider. The puncture is near lower right-hand corner. Highly magnified. (Author's illustration.)

distorted, and drop. Figure 5 shows an uninfested cotton plant for comparison with figure 7, infested. The lower leaves usually are first attacked, but infestation spreads upward until often only the bare stalk and one or two terminal leaves remain. (See fig. 8.) Such plants almost invariably die. The injury to the leaf and the discoloration which follows the feeding of the mites are easily understood by referring to figure 6, which represents (*a*) the appearance of healthy cotton leaf-tissues and (*b*) the condition of the tissue after feeding by the pest. As previously intimated, the worst spots of infestation are either to be found in close proximity to yards with borders of violets or to a clump of pokeweed stalks. Large fields are probably never completely damaged, but smaller fields frequently become wholly affected. A thorough examination of all fields within 1 mile of the center of Leesville, S. C., was made with a view of determining the exact status of red-spider infestation at one specific

locality. In all, 99 fields were examined as carefully as possible. The following table presents the results:

TABLE III.—*Results of an investigation to determine the degree of infestation of cotton by the red spider at Leesville, S. C., 1912.*

Degree of infestation.	Number of fields examined.	Per cent of total fields examined.
Very acute.....	18	18.2
Very considerable....	20	20.2
Slight.....	35	35.3
None.....	26	26.3
Total.....	99	100.0

Total number of fields visited..... 99
 Total number of fields infested..... 73
 Average percentage of infestation for the community..... 73.7



FIG. 7.—Cotton plant in an early stage of infestation by the red spider. Many leaves are discolored and some of the lower ones have dropped. (Original.)



FIG. 8.—Cotton plant in well advanced stage of infestation by the red spider. Nearly all leaves, squares, and bolls have been shed. (Original.)

This occurrence was one of the severest and most general that has at any time come to the writer's attention. Perhaps the most severe case in this locality (and one of the worst yet seen) was one which had its origin in a large clump of badly infested pokeweed stalks at the edge of town (fig. 9). The pest spread fanlike until it reached in one direction a point 600 feet from the pokeweed. The final affected area, semicircular in shape, comprised 13 acres, and within its confines the occurrence was general. While such a case as this was unusual, 4-acre or 5-acre spots, with 25 to 100 per cent damage, are frequently to be seen.

NATURAL CONTROLLING AGENCIES.

In both the seasons of 1911 and 1912 red-spider occurrence was most severe throughout July and early August. The last two weeks of August in both cases, however, witnessed so great a reduction of the pest that by the end of that month it was hardly noticeable, as a rule. This phenomenon, indeed, happens suddenly, and the agencies which work to produce it are unquestionably of great economic value. The ageing and toughening of the leaves at about this time may cause many mites to desert the cotton for other plants, but another factor of probably much greater importance is the increased abundance of several species of insect enemies which seem to gain dominance at just this time.

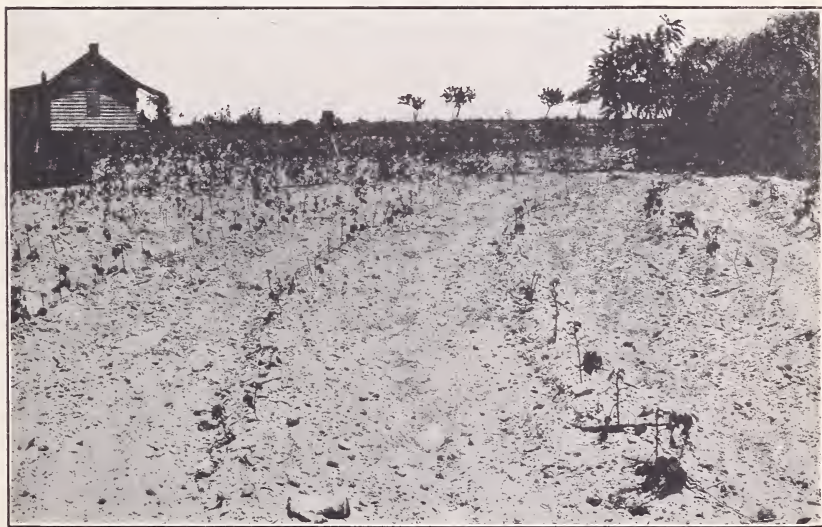


FIG. 9.—A severe example of red-spider work in a cotton field. Nearly all plants in the foreground are in the condition shown in figure 8. The source in this case was certain pokeweed stalks growing in the weed border seen in the upper right-hand corner of illustration. (Original.)

CLIMATIC INFLUENCES.

As before mentioned, climatic conditions exert a marked influence upon the welfare of the pest. During times of little rainfall and high temperature reproduction goes on by leaps and bounds; on the other hand, long, heavy rains work havoc to the red-spider population. In spite of the fact that the red spiders inhabit the underside of the leaves, many are washed off by rains and many more are destroyed by the upward bombardment of sand particles, which may always be seen coating the lower leaves after storms. In fact, it appears true that a few heavy rains, especially if they continue for some time, accomplish as much toward controlling the pest as

anything which can be done by man during the season. From observations made, both early in the season and at the beginning of winter, it is doubtless true that the young stages are killed by freezing weather. This naturally prevents any considerable winter increase, and in addition some adults probably perish.

The influence exerted upon the red spider by preseasonal conditions appears to be even greater than that of the factors operating in summer weather. The winter of 1911-12 was the severest in South Carolina for many years. Hence it might be expected that the following season would be a mild one, from the standpoint of injury by the red spider, through the assumed heavy mortality of the pest during the winter. On the contrary, as has been stated before, the 1912 occurrence was the severest on record. The only possible ex-

planation appears to embrace two suppositions. One is that the adult red spider is little susceptible to extreme cold. The other is that the insect enemies of the mites succumb much more easily to minimum temperatures than do the mites themselves. Both of these hypotheses are sustained by all observations of the writer. Naturally, then, a severe winter is precisely what would most favor the subsequent increase of

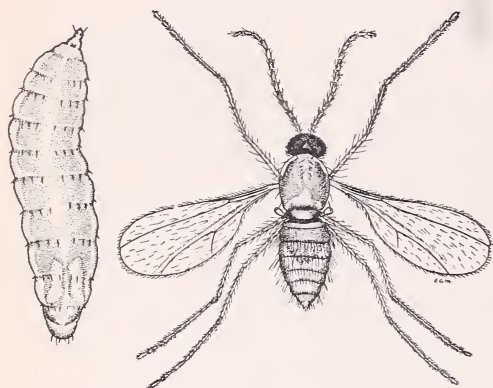


FIG. 10.—*Arthrocnodax* sp., a predaceous enemy of the red spider. At left, mature predaceous larva, magnified 60 times; at right, adult female, greatly enlarged. (Original.)

the red spider through the destruction of its insect enemies. Conversely, an abnormally mild winter, free from decidedly low temperatures, should furnish conditions most favorable for the survival of the repressive species, and the infestation for the following season would be mild.

INSECT ENEMIES.

Hot weather, although favoring red-spider development, probably encourages even more the increase of insect enemies, of which several have been observed. Were it not for these inconspicuous friends of the farmer the depredations to his crops by the red spider would unquestionably be more severe. The following are a few of the more important beneficial species observed during the season of 1912 at Batesburg, S. C.

Arthrocnodax sp.¹ (fig. 10).—During the season of 1912 a species of *Arthrocnodax*, a fly belonging to the family Itonidæ (formerly Cecidomyiidae), was first noticed toward the last of June, at which time it was not at all common. It increased very rapidly, however, and by the end of July had become quite abundant. It is the larva (grub stage) of this insect which assists the farmer, and the attack seems to be limited entirely to the red-spider eggs. Coming in contact with an egg, the larva instantly thrusts its piercing organ through the shell and begins to feed. Large larvæ will devour an egg in from one to two minutes, while the smaller larvæ require more time, according to their size. When mature, the larva spins a woolly cocoon 1 mm. in length. The adult fly issues after a brief pupal stage, and the full generation requires little time. This insect is probably the most effective enemy of the cotton mite, and to its final superabundance is probably largely due the late summer decimation of the red spider. It has been recorded from the following localities: Allendale, Anderson, Batesburg, Brownsville, and St. Matthews, S. C.; Chase City, Va.; Macon, Ga.; and Albertville and Boaz, Ala. It evidently has a wide distribution.

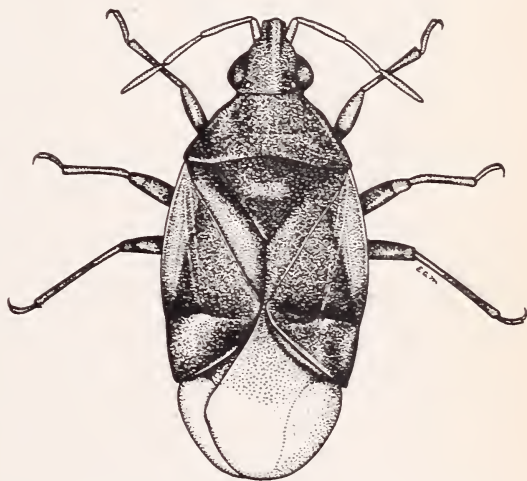


FIG. 11.—*Triphleps insidiosus*, an important enemy of the red spider: Adult. Much enlarged. (Author's illustration.)

Triphleps insidiosus Say (fig. 11).—A small anthocorid bug, *Triphleps insidiosus* Say, was seen as early as May 16. It is hardier than the *Arthrocnodax* and appears earlier in the season. Throughout July and August it is extremely common and both in the nymphal and adult stages is second only to the itonid as a red spider enemy. Coming upon a red spider, like a flash the adult thrusts its sharp proboscis through the pest's back and proceeds quietly to siphon out the body contents. The first victim observed was "drained" in about five minutes, but each succeeding meal was of shorter duration as the appetite became satisfied. The actions of the nymph (fig. 12) are similar, but the individuals observed were seen only to destroy eggs of the spider. In this operation

¹ The determination is by Dr. E. P. Felt.

the proboscis was not inserted far into the ovum, and two minutes sufficed for draining an egg.

A species of lace-winged fly (*Chrysopa quadripunctata* Burm., determined by N. Banks) is abundant at Batesburg throughout most of the summer, and its larva is doubtless very active in reducing the pest.

Two species of thrips, *Euthrips fuscus* Hinds and *E. occidentalis* Pergande, have been determined this season from cotton. They are commonly found throughout the season about red-spider colonies,

and may be instrumental in spider destruction. *Scolothrips sexmaculatus* Pergande has been recorded as an enemy of the red spider by Pergande and by Duffy.

Lady-beetle larvæ and adults of several species are commonly seen on infested leaves. These are usually either *Coccinella 9-notata* Hbst. or *Hippodamia convergens* Guér., but a small black species, (*Scymnus*) *Stethorus punctum* Lec., is frequently observed. The larger beetles are probably more intent upon cotton aphides, but the last-mentioned species, although later in ap-

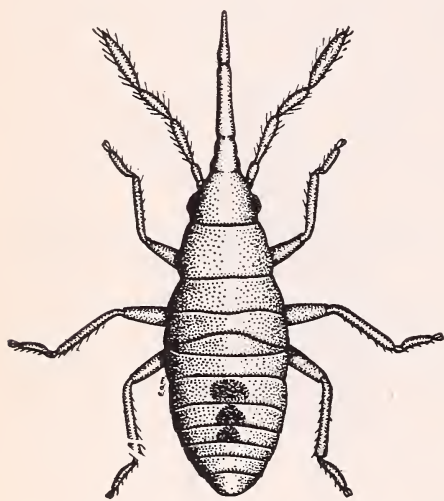


FIG. 12.—*Triphleps insidiosus*: Nymph. Greatly enlarged. (Author's illustration.)

pearing and not overnumerous, seems to be more restricted to the the cotton mite than are other species.

REMEDIAL MEASURES.

PREVENTION.

From the abundant experience of the past two years the writer has been forced to the conclusion that the eradication of the red spider must be accomplished through preventive efforts rather than repressive, if it is to be economically effected. The location of the mites through the winter and spring, their preference for the cultivated violet and the pokeweed, and the manner of dispersion of the pest lead to the presentation of the following cultural expedients.

Clean culture.—First among preventive measures against the red spider is doubtless that of exterminating the weeds and plants which breed the pest. Pokeweed, Jerusalem-oak weed, Jamestown weed, wild blackberry, and all border weeds and underbrush about fields should be burned or grubbed out during the winter or early spring.

This plan has been tested in several instances and has given complete immunity the following season. Too much emphasis can not be placed on the importance of destroying, so far as possible, all weed growth—especially the pokeweed, which should be grubbed out by the roots.

Control on violets.—As before stated, most cases of infestation in urban localities have their origin in borders of cultivated violets growing in near-by house yards. In several instances violets adjoining fields of past severe annual infestation have been thoroughly sprayed, with the result that no red spiders appeared subsequently in these fields. The objection to this treatment is the failure on the part of the average person to persevere with the spraying until the pests have been entirely exterminated. The most satisfactory procedure in such cases consists in the removal and destruction of the offending violets.

Varietal immunity in cotton.—From several tests conducted in different fields with numerous standard varieties of cotton, and from the information volunteered by farmers from many portions of South Carolina, data have been accumulated which clearly indicate that certain varieties are susceptible to red-spider infestation, while others exhibit considerable immunity. Careful observations on a considerable number of varieties grown for the purpose showed that Dixie "Wilt Proof," Toole, Peterkin, Broadwell, and Cook suffer most (in the order named) from the attack of the pest, while Hite, Russell, Summerour "Half and Half," and Cleveland showed the greatest immunity of all the varieties investigated.

Broadcasted cotton.—An opportunity was accidentally provided of testing the value of thickly broadcasting cotton at the boundary of a field as a trap crop for red spiders. This cotton, intended as a cover crop, intervened between the cotton field proper and a large, heavily infested border of violets—a former abundant source of migration. The broadcasted cotton became infested and was later plowed in. The adjoining field remained free from mites. The success of this experiment would strongly indicate that the cotton trap crop is a practical cultural expedient to be used in controlling this pest.

Spacing.—Experiments at Batesburg, S. C., have shown that the red spider commonly travels between plants upon the ground. This shows the futility of spacing as a remedial measure.

Time of planting.—There is yet much doubt as to the relative advantages of early and late planting. Extremely early planting naturally permits the plants to develop a maximum growth of weed and fruit by the time of serious mite appearance. It is noticeable that plants of considerable size are rarely killed by the pest, nor are well-advanced bolls commonly shed from infestation. On the other hand, several fields about Leesville, S. C., which were planted as

late as June 20 seem to have largely escaped the infestation which was so general at that locality. Late planting, however, is almost universally objectionable to the farmer, since in ordinary seasons it results in a reduction of the yield.

Rotation.—In an effort to test the rotational value of other crops, numerous field crops have been planted in or near infested areas. In addition, frequent examinations have been made of a great many garden and vegetable crops in infested localities. Besides cotton, red spiders are known to occur not at all uncommonly upon the following field crops: Cowpeas, clover, corn, hops, and watermelon. They are also found frequently on the following garden crops: Peas, beans, onion, tomato, lettuce, okra, turnip, mustard, squash, beet, sweet potato, and strawberry. A really acute infestation on corn (as above recorded) was seen at the height of the past season (1912). Cowpeas are particularly attractive to the pest, and sweet potatoes have been noted to be badly infested. Should an immune crop be found and employed, it is extremely probable that the pest would reinvade the fields upon the return to cotton culture with as great ease and quickness as it has done during any previous season, providing the sources of infestation were yet at hand. Rotation, then, does not promise to contribute toward the solution of the problem.

Effects of fertilizers.—A rather elaborate series of tests with fertilizers has been conducted in an attempt to determine whether the various applications assisted cotton to withstand the injurious effects of infestation. Since almost no infestation appeared in these test plats it was impossible to deduce positive conclusions.

REPRESSION.

We have just discussed cultural measures which may help to prevent infestation. We will now consider what may be done to combat the pest when it has already gained entrance to a field.

The writer believes in prevention rather than cure, in the case of the red spider. When once well established in a cotton field the pest is a most difficult one to wipe out. That it is possible, however, to eradicate the pest from infested fields has been demonstrated beyond doubt, but in many cases the task is so tedious that only the most determined farmers will undergo the effort necessary to accomplish the extermination.

Removal of infested plants.—The experiment has been thoroughly tested of pulling up and destroying the first few plants which show infestation. In such cases the operation was repeated several times. Great care was observed in locating every plant showing the characteristic red spots, and these were carefully taken from the field and burned. If infestation has not advanced far, this treatment is usually satisfactory, and a red-spider invasion often may be "nipped in the bud" and entirely eradicated.

If infestation has spread until a considerable patch has become involved it is sometimes advisable, in the case of a large field, to plow up all the affected portion in order to save the balance of the field. Such a drastic measure, however, should only be resorted to in extreme cases, and the planter concerned must be the judge of its advisability.

Occasional observations of instances wherein infestation had abruptly stopped at a much-traveled road suggested the idea of plowing a wide swath just outside the boundary of infestation. This was attempted in one case where the occurrence had covered about 2 acres. A 10-foot ring was plowed around the spot, and all stalks, both in the swath and in the inclosed area, were immediately burned. Unfortunately the farmer did not make sure that he was beyond the outermost zone of infestation, and consequently a sufficient number of affected plants remained outside the pulverized barrier to continue, somewhat, the dispersion of the pest. This idea should be given further tests, as it seems there should be great efficacy in the operation, provided the swath is kept stirred frequently.

Insecticides.—During the season of 1911, 26 spray combinations were thoroughly tested under conditions entirely natural. The field used for this purpose was about 1 acre in extent, and infestation had become both very general and very severe. A strip through the middle of the field, crossing each sprayed plat, was left unsprayed to serve as a check. Since no substance was discovered which could be safely used to destroy all eggs in one application, it was found necessary to spray twice, with an interval of six or seven days, so as to destroy the hatching larvæ. The killing ability of all these sprays was computed, and the percentages ranged from 100 to 0. Each of the following six combinations (see Table IV) was found to be very satisfactory. These are presented to indicate the manner of preparation, together with the cost, of 100 gallons of each.

TABLE IV.—*Some satisfactory sprays for use against the red spider.*

Spray No.	Formula and items.	Total cost.	Per cent killed.
I	Potassium sulphid, 3 pounds, at 25 cents..... Water, 100 gallons.	\$0.75	100
II	Flowers of sulphur, 15 pounds, at 4 cents } Fresh lime, 20 pounds, at 4 cents } boiled { \$0.60 Water, 100 gallons..... }80	1.40	100
III	Miscible oil, 5 gallons, at \$1..... Water to make 100 gallons (1 to 20).	5.00	100
IV	Potassium permanganate, 16½ pounds, at 50 cents..... Water to make 100 gallons (2 per cent solution).	8.25	100
V	Miscible oil, 2½ gallons, at \$1..... \$2.50 Blackleaf tobacco extract, 40% nicotine sulphate, 26 ounces, at \$1.25 per pound..... 2.00 Water to make 100 gallons.	4.50	99
VI	Flowers of sulphur, 28 pounds, at 4 cents..... \$1.12 Soft soap, 14 ounces, at 40 cents per pound..... .35 Water to make 100 gallons.	1.47	98

In the course of spraying tests against the red spider on hops in California, conducted by Mr. W. B. Parker,¹ of this bureau, it seems to have been demonstrated that flour paste, used alone or combined with caustic materials, is a valuable acaricide. The function of the flour paste appears to be twofold: Used alone it glues the tiny mites to the leaves, and when added to lime-sulphur, or other solutions, it serves as a spreader to prevent the spray film from breaking up into "beads" as it dries on the leaf. Mr. Parker recommends the following formulas:

I. Stock solution of flour paste.

Mix cheap wheat flour with cold water at the rate of 1 pound of flour to 1 gallon of water. Boil to a paste.

II. Flour-paste spray.

Use 8 gallons of the above stock-solution paste to each 100 gallons of water. Keep constantly agitated while spraying.

III. Lime-sulphur and flour-paste mixture.

Use 4 gallons of flour-paste stock solution to each 100 gallons of lime-sulphur spray.

During the recent season no serious effort was made to test additional insecticides. Further use of the sprays mentioned, however, seems to establish the superiority of potassium sulphid, lime-sulphur solution, and miscible-oil-tobacco solution. The last preparation seems to possess better lasting qualities than the others, since, in the absence of rain, one application will also suffice to kill a certain percentage of the hatching larvæ. If one of these were to be used in preference to all others, it would probably be potassium sulphid. This insecticide commends itself from every standpoint—cheapness, simplicity of preparation, ability to kill quickly, and safety of foliage. Altogether it seems to be an ideal red-spider spray. It was found that 100 gallons, when applied as a mist spray, about sufficed to treat an acre of average-sized cotton.

Spraying outfits.—The sort of outfit to be used for red-spider spraying depends mainly upon the extent of the occurrence. Some have sprayed their score or so of affected plants with a 75-cent tin atomizer. While this instrument is very economical of liquid and throws a misty spray which penetrates and blows to all parts, it is not economical of time. The bucket pump and knapsack pump come into use in cases of considerable scattered infestation or for the treatment of a few high plants. The most economic outfit for a severe case involving several acres consists of a barrel pump carried through the field on a wagon. One man drives, one pumps, and one handles each sprayer (of which preferably there should be two). Thorough treatment of 3 or 4 acres per day is readily obtainable with this device. For safe work, however, this outfit should be used only

¹ Flour paste as a control for red spiders and as a spreader for contact insecticides, Cir. 166, Bur. Ent., U. S. Dept. Agr., January 30, 1913; The red spider on hops in the Sacramento Valley of California, Bul. 117, Bur. Ent., U. S. Dept. Agr., 1913.

on cotton of average or low size, as the passing wagon will injure large plants.

Necessity for thorough spraying.—Some dissatisfaction has been experienced among certain of those who have undertaken to check the ravages of the red spider by spraying. This can be understood on account of the extreme care which must be exercised in order to secure effective results. In the case of insects which devour the plant tissue even the careless application of Paris green or lead arsenate to the top of the foliage is often effective. This is explained by the fact that such pests are constantly moving from leaf to leaf and will eventually eat some of the poisoned tissue. Moreover, these insects often eat entirely through the leaf, and hence it matters little whether the poison falls upon one side or the other. With the red spider, however, it is altogether different. A contact insecticide is absolutely necessary, and, from the fact that the mite as a rule passes its entire existence upon the underside of a single leaf, it becomes plainly necessary in spraying to *hit the entire underside of every leaf* of an infested plant. It is obvious, therefore, that indifferent spraying is certain to yield unsatisfactory results. Furthermore, the absolute necessity for a second spraying to kill the hatched eggs adds to the difficulty.

It is hoped that this discussion may impress upon the reader *the economy of prevention* of infestation.

SUMMARY.

The female red spider, appearing to the naked eye like a dot of reddish ink from the point of a fine pen, lays about 50 or 60 round, colorless eggs, which hatch in summer time in about four days.

The colorless, newborn spider has six legs, feeds at once, and molts in two days to the primary nymph.

This first nymphal stage (and all later stages) possesses eight legs, and has become larger in size and darker in color. In two more days (in summer) it, in turn, molts to the secondary nymph.

The second nymphal stage lasts two days, at the end of which time, after molting, the fully formed adult emerges. Mating occurs at once and egg laying commences immediately afterwards.

Thus one generation requires in summer weather in South Carolina about 10 or 11 days. There are probably about 16 or 17 generations in an average year in that locality.

The red-spider colonies live on the underside of the cotton leaves, and their constant feeding causes blood-red spots to appear on the tops of the leaves. The effect upon the cotton plant is that the leaves drop, one by one, until usually the plant dies.

The pest increases and spreads most rapidly in hot, dry weather until (toward the end of August) several acres of a field may become badly damaged.

Several insects have been discovered which destroy many mites and are thus of great benefit to the planter.

At the end of the cotton-growing season most of the red spiders migrate afoot in search of greener plants. The majority of those which are destined to survive the winter probably settle on either the cultivated violet or on the pokeweed.

RECOMMENDATIONS.

(1) *Clean culture*.—Destroy, by burning and grubbing out, all weeds and underbrush about cotton fields, being especially careful to remove all pokeweed. Practice fall plowing so far as possible.

(2) *Control on violets*.—Destroy or thoroughly spray cultivated violet plants which may be growing near cotton fields.

(3) *Resistant varieties*.—In choosing seed for the crop avoid varieties which suffer most from red-spider attack.

(4) *Broadcasted trap borders*.—Thickly sow cotton along margins of fields at points where infestation has appeared on former occasions and plow these in about June 1, so as to intercept and destroy the invading mites.

(5) *Pulling first infested stalks*.—Maintain a careful watch of fields from the time of the earliest appearance of cotton above ground, so that the first attacked plants may be detected, removed, and burned, thus preventing further spread.

(6) *Barrier strip*.—In case a considerable area of cotton has become affected before discovery, remove and burn the worst of it and then plow a 10-foot strip completely around the extreme outside of the infested area. Keep this strip stirred frequently to make further dispersion difficult.

(7) *Spraying*.—Apply one of the insecticides recommended to the infested portion of a field before infestation becomes too general to prohibit its use. Choose the pump outfit which best suits the particular case. Two applications should be made. The second, a week after the first, is to kill the individuals which were eggs at the time of the first spraying.

Unlike many other pests, the red spider has no wings and spreads mainly by means of its tiny legs. Migration does not extend far from its winter quarters. This makes every man's problem virtually his own. In other words, if his infestation always comes from a certain spot upon his premises, proper attention to this spot will yield him satisfactory results in spite of the negligence of his neighbors.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., January 22, 1913.

